

MEMORANDUM

To: Ken Merrill
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From: Joel Massmann, Ph.D., P.E.

Date: July 21, 2012

Subject: Frequency and Magnitude of Violations of
the Kalispel Tribe's Temperature Criteria

This memorandum summarizes results of analyses of the frequency and magnitude of violations of the Kalispel Tribe's temperature criteria for those portions of the Pend Oreille River that are within the Tribe's territorial jurisdiction. The analyses are based on the results of temperature modeling that has been completed as part of the temperature TMDL for the Pend Oreille River published by the Department of Ecology (Baldwin et al., 2011). The analyses also consider the relationship between the amount of heat that is transported across the Washington-Idaho Stateline and compliance with the Kalispel Tribe's temperature criteria and whether Ecology's temperature TMDL will ensure compliance with the Tribe's water quality criteria.

The results summarized below were developed based on analyses that are described in a series of memoranda prepared for the Kalispel Tribe. These memoranda provide additional detail and are identified in the reference list.

A. The Kalispel Tribe's Temperature Criteria for the Pend Oreille River

Under Chapters 11 and 12(b) of the Kalispel Tribe's water quality standards, the following temperature criteria apply to the Pend Oreille River at all times:

Temperature shall not exceed 18°C as a moving 7-day average of the daily maximum [7-DADMax] temperatures with no single daily maximum temperature [1-DMax] greater than 20.5°C. When natural background conditions prevent the attainment of the numeric temperature criteria, human-caused conditions and

activities considered cumulatively can increase temperature levels by only an additional 0.3°C.

The Tribe has asked me to determine compliance with these standards based on their following interpretation:¹

“These criteria are spatially and temporally sensitive. They require comparison of the maximum water temperature at the same location on the same day under existing and natural conditions unless this day-to-day comparison would result in inaccurate characterization of impairments. A violation of the Tribe’s temperature criteria occurs where any of the following four conditions are met:

- 1. natural 7-DADMax $\leq 18^{\circ}\text{C}$, and existing 7-DADMax $> 18^{\circ}\text{C}$;*
- 2. natural 7-DADMax $> 18^{\circ}\text{C}$, and existing 7-DADMax $> \text{natural 7-DADMax} + 0.3^{\circ}\text{C}$;*
- 3. natural 1-DMax $\leq 20.5^{\circ}\text{C}$, and existing 1-DMax $> 20.5^{\circ}\text{C}$; or*
- 4. natural 1-DMax $> 20.5^{\circ}\text{C}$, and existing 1-DMax $> \text{natural 1-DMax} + 0.3^{\circ}\text{C}$.”*

B. Objectives and Scope

The objectives and scope of the analyses summarized in this memorandum are as follows:

1. Based on the requirements above and the data generated by the CE-QUAL-W2 model employed in the Department of Ecology’s Pend Oreille River Temperature TMDL, determine the frequency and magnitude of any violations of the Kalispel Tribe’s temperature criteria for those portions of the Pend Oreille River that are within the Tribe’s territorial jurisdiction.
2. After conducting this analysis, explain whether Ecology’s TMDL will ensure compliance with the Tribe’s water quality criteria.

C. Temperature Simulations Derived from the CE-QUAL-W2 Model

The Kalispel Tribe’s water quality standards described above require estimates of temperatures under existing and natural conditions. These temperature estimates are derived using the CE-QUAL-W2 model employed in the Department of Ecology’s Pend Oreille River Temperature TMDL (Baldwin et al., 2011). The existing condition scenario simulates flow and temperatures with existing impoundments while the natural conditions scenario simulates flow without dams. The model results for these scenarios

¹ This memorandum represents the first analysis that I have completed using the Tribe’s interpretation of their water quality standards. Previous work described in earlier memoranda considered violations associated with conditions 2) and 4) described above. Violations associated with conditions 1) and 3) were not considered.

were obtained from the Department of Ecology. The model runs that were compared are listed in Table 1. The comparison of simulations described in this memorandum focuses on the period 1/14/2004 to 12/31/2004. This is the same period used in Ecology's TMDL.

The output from the CE-QUAL-W2 model provided by the Department of Ecology includes five types of temperature statistics for each segment used to represent the river. Unless stated otherwise, all temperatures used in this analysis are the maximum temperature in the segment. These are the same temperature values used by the Department of Ecology in their TMDL analysis (Baldwin et al., 2011).

Table 1. Model runs used in comparison

Model	Scenario	Model run time	Developer
Box Canyon	Existing	14:12:41 on 02/12/09	Portland State
Box Canyon	Natural	16:28:52 on 06/29/07	Portland State

D. Analysis of Compliance with the Kalispel Tribe's Criteria

The Kalispel Tribe's temperature criteria are based on comparisons of daily maximum temperatures under natural and existing conditions. The computer models developed by Portland State and used by the Department of Ecology in their TMDL are used to generate temperature predictions at 30-minute intervals. These relatively high-frequency estimates can be used to calculate the daily maximum temperatures and the 7DADM temperatures necessary to evaluate compliance with the Kalispel Tribe's criteria.

Violations of the Kalispel temperature criteria were identified by comparing directly on a one-to-one basis both daily maximum temperatures and the seven-day average of the daily maximum temperatures under existing and natural conditions. If the temperature difference between natural and existing conditions exceeds the allowable increase, a violation was noted. The magnitude of the violation is defined as the difference between the allowable temperature increase and the actual temperature increase.

The number and magnitude of violations of temperature criteria at the upstream end and adjacent to the Kalispel Reservation based on the 2004 model simulations are summarized in Table 2. There are violations on 37 days during the period 6/29/04 to 9/9/04. This translates into a violation on 51% of the days during this period. The average violation is 0.35 degree C and the maximum violation is 0.87 degree C. Violations occur on 87% of the days during the three-week period from 8/9/04 to 9/1/04.

Table 2. Violations of the Kalispel Tribe's temperature criteria. All values are deg C.

Date	Type of Violation ¹	Location of Violation	Magnitude of Violation	Temperature under existing conditions		Warming between RM 88 and RM 72
				RM88	RM72	
06/29/04	Type 3	RM64	0.34	19.53	20.23	0.70
06/30/04	Type 3	RM66	0.03	18.66	20.03	1.38
07/10/04	Type 3	RM72	0.16	20.60	20.66	0.06
07/11/04	Type 3	RM72	0.27	20.41	20.77	0.36
07/18/04	Type 4	RM64	0.01	21.53	22.79	1.26
07/27/04	Type 4	RM72	0.17	23.51	24.59	1.08
07/28/04	Type 2	RM72	0.04	23.44	24.38	0.95
07/29/04	Type 4	RM72	0.06	23.47	24.49	1.02
07/30/04	Type 4	RM72	0.58	23.34	24.50	1.16
07/31/04	Type 4	RM72	0.19	23.40	24.47	1.07
08/04/04	Type 4	RM64	0.10	23.55	24.42	0.87
08/09/04	Type 2	RM72	0.05	23.15	23.72	0.57
08/10/04	Type 4	RM72	0.24	23.43	24.10	0.67
08/11/04	Type 4	RM72	0.69	23.68	24.56	0.88
08/12/04	Type 4	RM72	0.80	23.61	24.81	1.20
08/13/04	Type 4	RM64	0.68	23.65	24.80	1.15
08/14/04	Type 4	RM64	0.65	23.79	24.87	1.08
08/15/04	Type 4	RM64	0.61	23.83	25.01	1.18
08/16/04	Type 4	RM64	0.59	23.92	25.10	1.18
08/17/04	Type 4	RM64	0.02	23.74	24.83	1.09
08/18/04	Type 4	RM64	0.09	23.74	24.76	1.02
08/21/04	Type 4	RM64	0.35	23.81	24.27	0.45
08/23/04	Type 4	RM72	0.21	22.38	22.29	-0.10
08/25/04	Type 2	RM72	0.13	21.78	21.10	-0.69
08/26/04	Type 2	RM72	0.29	21.63	21.42	-0.21
08/27/04	Type 3	RM72	0.83	21.50	21.33	-0.18
08/28/04	Type 3	RM72	0.72	21.08	21.22	0.14
08/29/04	Type 3	RM72	0.74	20.97	21.24	0.26
08/30/04	Type 3	RM64	0.86	20.90	21.23	0.33
08/31/04	Type 3	RM64	0.87	20.75	21.26	0.51
09/01/04	Type 3	RM64	0.44	20.65	20.78	0.13
09/04/04	Type 2	RM72	0.04	19.55	19.54	-0.01
09/05/04	Type 2	RM72	0.15	19.58	19.75	0.17
09/06/04	Type 2	RM72	0.26	19.38	19.82	0.44
09/07/04	Type 2	RM72	0.35	19.27	19.45	0.18
09/08/04	Type 2	RM72	0.31	19.01	19.72	0.71
09/09/04	Type 2	RM72	0.16	18.76	19.21	0.46
Average violation:			0.35			
Maximum violation:			0.87			

¹Type 1: natural 7-DADMax ≤ 18°C, and existing 7-DADMax > 18°C;

Type 2: natural 7-DADMax > 18°C, and existing 7-DADMax > natural 7-DADMax + 0.3°C;

Type 3: natural 1-DMax ≤ 20.5°C, and existing 1-DMax > 20.5°C; or

Type 4: natural 1-DMax > 20.5°C, and existing 1-DMax > natural 1-DMax + 0.3°C.

E. Evaluation of Whether Ecology's TMDL Will Ensure Compliance with the Tribe's Criteria

The approach used by the Department of Ecology to evaluate compliance with the Kalispel Tribe's temperature criteria is described on pages 28-30 in the 2011 TMDL. Ecology's approach is based on a seasonal cumulative frequency distribution (CFD) analysis to evaluate compliance with water quality standards. The seasonal CFD approach is a statistical approach that involves pooling data over time periods of several months. The approach results in temperatures under natural conditions from one part of the pooling period being compared to temperatures under existing conditions from a different part of the pooling period.

The maximum and average temperature differentials between natural and existing conditions as calculated using Ecology's cumulative frequency distribution approach are summarized in Table 3. The maximum differential for the location immediately above the Kalispel Reservation (RM 72) is 0.6 degree for the daily maximum criteria and is 0.4 degrees for the 7DADM criteria (Baldwin et al., 2011, page 51). A comparison of the results from Ecology's seasonal CFD approach shown in Table 3 with the pair-wise comparison results in Table 2 shows that Ecology's approach under-estimates the magnitude of the temperature violation by a factor of approximately 1.5 (0.6 degrees versus 0.9 degrees).

The river flow on the day with the maximum temperature violation shown in Table 2 (8/31/04) was approximately 21,200 cubic feet per second (cfs). As a point of reference, a continuous source of boiling water ($T=100$ degrees C) would need to be added to the river at a rate equal to 54 million gallons per day (84 cubic feet per second) to raise the temperature by 0.3 degrees under these flow conditions.

The cumulative frequency analysis does not characterize the differences between natural and existing temperature conditions in a manner that is consistent with the Tribal water temperature criteria. The Tribal temperature standards require a time-based comparison of daily maximum temperatures. These standards do not consider the persistence of temperatures above or below prescribed levels and they do not consider seasonal impacts or seasonal differences. By pooling data over a 93-day period, Ecology's cumulative frequency analysis evaluates seasonal differences in temperature. This seasonal metric does not comport with the 1-day maximum criteria of Kalispel water quality standards, which require that temperature impairment be determined on a day-by-day basis. Furthermore, the cumulative frequency analysis used in the Pend Oreille TMDL is non-conservative because it results in maximum temperature differences that are always less than or equal to the differences that would be derived from a direct pair-wise comparison of temperatures for the same date and location.

Table 3. Results from Ecology's Cumulative Frequency Distribution Approach (from Baldwin et al., 2011, Table 7, page 52)

Criteria	Above the Kalispel Reservation (RM 72, Segment 115)		Below the Kalispel Reservation (RM 63.6, Segment 172)	
	Average differential	Maximum differential	Average differential	Maximum differential
Kalispel daily maximum	0.06	0.60	-0.50	0.22
Kalispel 7DADM	-0.03	0.40	-0.51	0.14

F. Incorporating effects of time-lag

The Pend Oreille TMDL document lists several reasons for why Ecology used the seasonal cumulative frequency distribution approach (Baldwin et al., 2011, page 26). These reasons generally revolve around presumed altered travel times or time lags.

There is no evidence to suggest that altered travel times or time lags are important with regard to violations of the Kalispel Tribe's temperature violations within their territorial jurisdiction. Figure 1 shows the temperatures under existing and natural conditions at RM 72. This location represents the upstream end of the Kalispel Tribe's reservation and is the location where most of the temperature violations listed in Table 2 occur. Inspection of Figure 1 shows there is very little, if any, time lag between natural and existing temperatures during the summer months. The temperature time lag between existing and natural conditions during the critical summer period is one day or less.

The effects of time shifts on the frequency and magnitude of temperature violations at the upstream end of the Kalispel Tribe's reservation are shown in Table 4. These effects were calculated by shifting the time scales for temperatures for the natural and existing conditions. A plus-1 (+1) day time shift means that the daily maximum temperatures for natural conditions were compared to the next day's daily maximum temperatures for existing conditions. A minus-1 (-1) day time shift means that the daily maximum temperatures for natural conditions were compared to the previous day's daily maximum temperatures for existing conditions. The results shown in Table 4 indicate that the minimum number of violations occurs with a times shift of approximately 1 day. The magnitude of the maximum violation at RM 72 is lowest with no time shift.

The results included in Table 4 further confirm that time lags or altered travel times are not significant with regard to violations of the Kalispel Tribe's temperature violations within their territorial jurisdiction. There is no technical reason for using seasonal cumulative frequency distribution approach to address time lags or altered travel times at these locations.

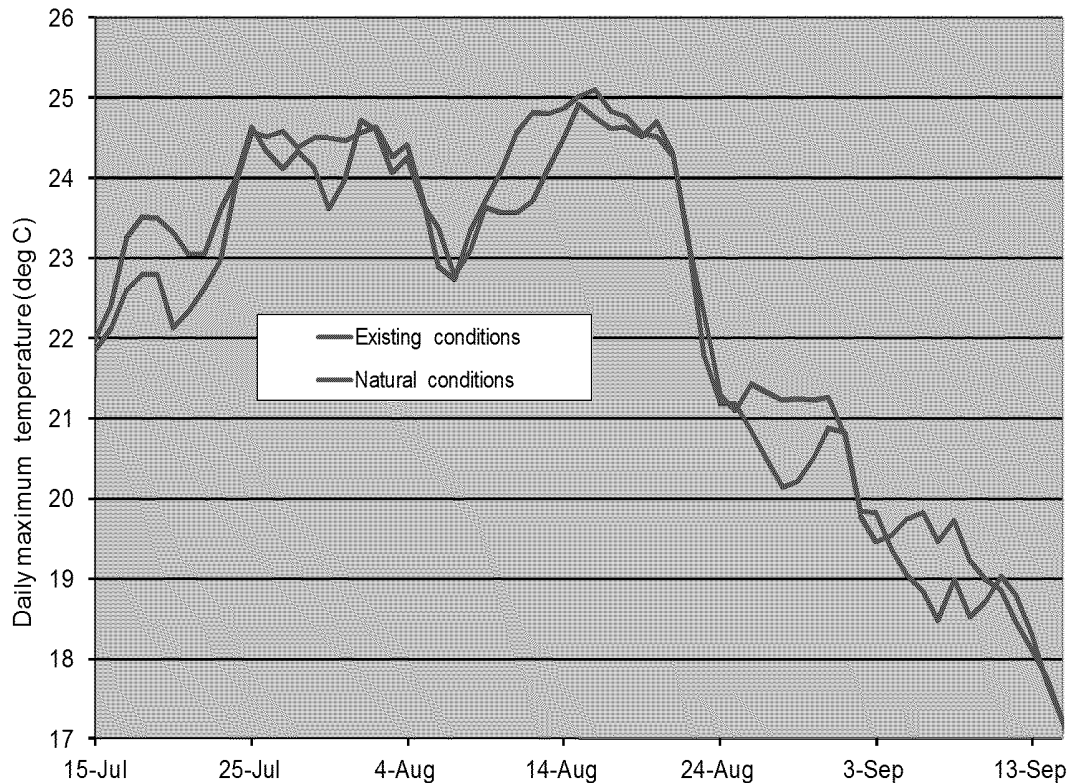


Figure 1. Comparison of temperatures under existing and natural conditions at the upstream end of the Kalispel Tribe's reservation (River Mile 72)

Table 4. Effects of time shifts on the frequency and magnitude of temperature violations

Shift	RM 72	
	Frequency	Magnitude
+0	29	0.83
+1	28	0.94
+2	33	0.95
+3	33	1.22
+4	35	1.48
-1	43	1.15
-2	44	2.19
-3	40	2.79
-4	40	3.04

G. Ecology's Assumption Regarding Temperature and Heat Flow at the Idaho/Washington Stateline

Temperature and flow conditions in the Pend Oreille River at the Idaho/Washington Stateline affect temperatures in the river immediately above and within the Kalispel Reservation . The results of the computer simulations developed for the TMDL show that heat flow is greater under existing conditions on most days when the Kalispel

temperature criteria are violated (Keta Waters, August 2010). These days are highlighted in Table 2 above.

Ecology has concluded that water flowing from Idaho across the Idaho/Washington Stateline is cooler under existing conditions than under natural conditions (Baldwin et al., 2011, page 73). This conclusion is apparently a result of using the cumulative frequency distribution approach and does not consider specific time periods during the summer months when the water flowing across the Stateline is warmer under existing conditions as compared to natural conditions.

Ecology further assumes that in the future river temperatures will be cooler than under natural conditions. According to Ecology, this "stateline assumption" provides a baseline for establishing load allocations downstream (Baldwin et al., 2011, page 73). Ecology provides a 0.3 degree C allocation in heat load to the river downstream of the Stateline as a result of their conclusion that water flowing from Idaho is cooler under existing conditions (Baldwin et al., 2011, page 79).

A 0.3 degree C heat load allocation downstream of the Stateline will allow even higher temperatures for those portions of the Pend Oreille River that are within the Tribe's territorial jurisdiction. These higher temperatures will increase the frequency and magnitude of violations of the Kalispel Tribe's temperature criteria.

References

- Baldwin, Karin, Anthony J. Whiley and Paul J. Pickett, 2011. *Pend Oreille River Temperature Total Maximum Daily Load Water Quality Improvement Report*, Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington, Publication No. 10-10-065, November, 2011 *Revised*.
- Keta Waters. 2009. *Review of temperature modeling, Pend Oreille River*, June 16, 2009 memorandum to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department.
- Keta Waters, 2010. *Approaches for comparing predicted temperatures for the Pend Oreille River under existing and natural conditions*, August 10, 2010 memorandum to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department.
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- Keta Waters, 2012. *Pend Oreille River Temperature TMDL Cumulative Frequency Analysis*, March 6, 2012 memorandum to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department.